Dude, Where's My Resilience? The Case for Energy Resilience Benefit Valuation in Building Energy Code, Policy, and Program Cost-Effectiveness

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ABSTRACT

This paper argues that it is within the life-safety and general welfare mission of building codes to include energy resilience measures that protect occupants during prolonged power outages, which will become increasingly common as the result of extreme weather. To that end, this paper proposes a novel and expanded definition of *building energy resilience* as related to but distinct from energy resilience and energy system resilience. This proposed definition draws from and expands upon the concepts presented by the DOE and others. It goes beyond passive survivability and grid interactivity to emphasize active systems that contribute to a building's operation independent of the grid. Quantifying the benefits of energy resilience is essential for justifying the incremental first costs of addressing risks associated with extreme weather and grid disruption events. Fortunately, applicable frameworks already exist. This paper surveys the historical purview of building and energy codes; analyzes existing definitions of resilience and the need for a more comprehensive definition, and outlines the safety, health, and general welfare benefits of energy resilient building design and construction. Finally, the paper presents precedents, metrics, and methodologies for (1) valuing energy resilience benefits and (2) integrating energy resilience into energy codes, policies, and programs. The paper concludes with recommendations for how policymakers and decisionmakers can integrate resilience benefit valuation into energy cost-effectiveness and development processes.

Introduction

Energy codes have been an instrumental policy tool for maintaining energy affordability and energy security over the past half century, since the Energy Policy and Conservation Act (EPCA) of 1975 created the U.S. Department of Energy (DOE), and ASHRAE 90-1975 was introduced as the first national model energy code for residential and commercial buildings (U.S. Department of Energy, 2026a) (U.S. Department of Energy, 2026b). Since then, energy codes in the U.S. are estimated to have saved $60 billion in energy costs and are projected to save over $100 billion and 841 million tons of CO2 emissions between 2012 and 2040 (U.S. Office of Energy Efficiency & Renewable Energy, 2016).

More recently, energy codes have been used to advance outcomes that align with energy priorities beyond efficiency and costs, such as climate policy goals related to renewable energy deployment and emissions reductions; electrification, electric grid integration and grid resilience; and building energy resilience. This progression is evident in the introduction of renewable energy as a referenceable energy technology and credit in the Energy Cost Budget (ECB) method of ASHRAE 90.1-1999, renewable energy's inclusion as an additional efficiency package option in the 2012 International Energy Conservation Code (IECC), and the later introduction of demand responsive and load management technologies as additional efficiency credits in the 2021 IECC and ASHRAE 90.1-2022 (ASHRAE, 1999) (International Code Council, 2012). Allowances, credits, and requirements for these technologies have been maintained and advanced in the subsequent model code cycles since their introduction.

When introduced in the 1970s, energy codes were a response to that decade's energy crisis and high energy prices. Today, many states are similarly using energy codes as a policy lever to respond once again to rising energy prices, rising electricity demand, and climate change. For example, 24 states—representing 53% of the U.S. population— have commitments to 100% clean energy, and 130 U.S. cities joined the UN Cities Race to Zero campaign in 2021, many of which are going beyond national model codes to help reach these goals (Clean Energy States Alliance, 2026) (C40 Cities, 2021).

Recent research has explored how energy codes can advance grid-interactive efficient building (GEB) technologies that can provide over $100 billion in cost savings to electric system and infrastructure upgrades over the coming decades (Franconi, Rosenberg, & Hart, 2021). Research is also showing how efficiency improvements meeting or exceeding the 2021 IECC can make buildings safer for occupants, reducing excess mortality during extreme weather events (Franconi, et al., 2023). There is ample evidence that codes are a powerful adaptation tool for the built environment. Despite these findings, current national model code development processes—including cost-effectiveness tests and methodologies—are obstacles to energy resilience measures being incorporated into building codes.

While the first costs of building energy measures are well understood, the full range of benefits are typically overlooked and undercounted in cost-effectiveness tests and methodologies. Quantifying and considering the benefits of energy resilience is essential for justifying the incremental first costs of addressing risks associated with extreme weather and grid disruption events. This paper argues that energy resilience—and specifically *building energy resilience* as introduced below—is a crucial aspect and benefit of energy codes that fits within the life-safety scope of building codes. It presents frameworks for energy resilience benefit valuation that should be included in energy code cost-effectiveness tests.

Layers of Energy Resilience

Defining Energy Resilience

Definitions of resilience in buildings vary but generally cite the dual nature of resilience impacting both the building and its occupants, the multiple factors of both resistance and responsiveness to hazards, and the time component of short or prolonged exposure and post-event recovery (Rehman, Hamdy, & Hasan, 2024) (Bianchi, et al., 2025). In this paper, resilience in buildings and the built environment is understood as the capacity for buildings and infrastructure and their users or occupants to withstand, respond to, and recover from acute and chronic shocks, stressors, and disruptions (Franconi, et al., 2024).

The provision and maintenance of energy is a fundamental component of building resilience. Energy powers critical community infrastructure like hospitals, water treatment plants, and transportation; it gives buildings the power needed to operate building-level heating, cooling, ventilation, and lighting systems; run refrigeration for food and medicine storage; and power medical devices.

Most research on energy resilience has focused on energy-system-level resilience, recognizing that energy has historically been generated and distributed in a centralized way (Jasiunas, Lund, & Mikkola, 2021). Advancements in distributed energy technologies, improvements in the high-performance design and construction of buildings, and the capacity for buildings and end-use loads to function interactively with the grid make it increasingly challenging to delineate clear boundaries between the energy system and buildings. Additionally, the deployment of many building-, campus-, and community-level microgrids that allow energy generation and maintenance at the sub-system level are critical to broader system- and component-level energy resilience. Consideration of energy resilience at these relatively smaller scales can support layers of redundancy that improve life safety and health outcomes for communities and building occupants when grid-level systems fail, while also contributing to grid-level reliability.

Energy System Resilience

The International Energy Agency (IEA) defines *energy system resilience* as, "[t]he capacity of the energy system and its components to cope with a hazardous event or trend, to respond in ways that maintain its essential functions, identity and structure as well as its capacity for adaptation, learning and transformation. It encompasses the following concepts: robustness, resourcefulness, recovery" (IEA, 2015). Literature reviews have further identified energy security as an embedded or interrelated concept, which IEA defines as, "uninterrupted availability of energy sources at an affordable price" (Jasiunas, Lund, & Mikkola, 2021). While energy system resilience is necessary to ensure energy affordability, life safety, and a functioning economy, inevitable interruptions at the system level leave communities, buildings, and occupants vulnerable – especially during extreme weather events. The potential for system failure to result in cascading failures and vulnerability is evidenced in the 2021 fallout during and following Winter Storm Uri in Texas, when over 4.5 million people lost power for days, contributing to over 246 deaths across the state (Grid Strategies LLC 2022). In addition to suffering and loss of life, extreme weather events that cause prolonged power outages often result in costly cascading effects as a direct result of energy system failure (e.g., frozen and burst pipes and water damage, mold due to reduced dehumidification); (re)construction and relocation costs, and residential and commercial food spoilage.

Building Energy Resilience

Research has not yet agreed on a definition of "building energy resilience." One can draw from existing literature on "resilience," "energy resilience," and "energy system resilience" to understand current applications and meanings of "resilience" in the context of integrated building and energy systems. The DOE describes energy resilience as comprising two core functions: passive survivability and grid resilience, a characterization that has been noted in additional resources and research including the Illinois Smart Energy Design Assistance Center (U.S. Department of Energy, 2026a) (Smart Energy Design Assistance Center, 2024). While this characterization helps clarify the relationship between building-level energy measures and the broader energy grid, it is limited by identifying only passive survivability at the building level and grid resilience. It ignores (1) the possibility of buildings or groups of buildings continuing to function with microgrids during a grid disruption and (2) how active systems can support both building- and grid-level resilience. Examples of such active systems include generators and distributed energy resources (DERs) such as renewable generation and electric energy storage, bi-direction EVs, and thermal energy storage.

This paper proposes a novel and expanded definition of building energy resilience as related to but distinct from broader energy resilience and energy system resilience. This proposed definition draws from and expands upon the concepts presented by the DOE and others. It goes beyond passive survivability and grid resilience to emphasize active systems that contribute to a building's energy resilience *independent of the electric grid*:

> ***Building Energy Resilience:*** *The capacity for a building to withstand, respond to, and recover from acute and chronic stressors that impact the maintenance of energy-critical functions such as habitable thermal conditions; the provision of lighting, fresh air, pumping of potable water; and the powering of medical, refrigeration, and communication devices. Energy resilient buildings incorporate one or more of three core functions: passive survivability, grid-interactive efficient building (GEB) technologies, and the design and use of active systems, including distributed energy systems (DERs) that enable buildings and building systems to function independently of the grid.*

Under this expanded definition and framework, buildings actively contribute to energy system resilience while withstanding system-level failures and protecting their occupants during those failures.

Codes Are Intended to Protect Life Safety and Quality of Life

Building codes have historically been intended to protect life-safety and quality of life. The ancient Babylonian Code of Hammurabi is frequently cited as the earliest example of a building code, as is its intent to protect life-safety (Eisenberg, 2006) (Bruner, 2019). Fast forward a few thousand years, and American cities were creating and enforcing building regulations to protect people and structures against fire, overcrowding, and inadequate natural light and ventilation. These activities advanced through the late 1800s and early 1900s with the National Bureau of Fire Underwriters (NFBU) publication of the NBFU No.70 (the precursor to the National Electric Code, first published in 1897), and later their Building Code (California CREIA, 2026) (Mathewson, 2023). The International Code Council (ICC), publisher of the most broadly referenced and adopted U.S. model building codes, lists in their core values a vision to "…make our buildings safe and our communities more resilient." (International Code Council (ICC), 2026).

While provisions for emergency and standby power systems have been present in the IBC since the year 2000, they are limited to 2-hour duration and only cover certain critical loads related to fire prevention, smoke control, emergency alert, and emergency egress systems. The structure of these requirements tacitly acknowledges that without power, a building built to the code is not habitable for long and will be evacuated.

Codes Can—and Should—Respond to Modern Risks with Energy Resilience Measures

As seen during Winter Storm Uri and the Pacific Northwest Heat Dome of 2021, extreme weather and grid disruption are deadly events that modern building design and construction must confront. The combination of unprecedented load and demand growth and extreme weather are straining the electric grid and raising the risk of major grid disruption events. The North American Electric Reliability Corporation's (NERC) 2026 reliability assessment indicated 8 of 23 grid assessment areas as having elevated risk for resource inadequacy, with another 5 as high-risk (NERC, 2026). The World Health Organization (WHO) cites approximately 489,000 annual heat-related deaths globally from 2000-2019. Heat-related deaths are expected to climb as climate change and atmospheric warming progress through the century (World Health Organization, 2024).

Given the likelihood of short-, medium-, and long-term grid disruption throughout the U.S., it is not enough for building codes to provide emergency power for egress and evacuation; they must also meet minimum requirements that preserve building habitability and life safety during short and extended grid disruption events through design and construction practices incorporating building energy resilience.

How Energy Code Cost-Effectiveness is Currently Calculated

The DOE Building Energy Codes Program, in partnership with PNNL, develops and publishes methodologies for evaluating the performance of residential and commercial energy codes in the context of first-costs and life-cycle energy performance and cost (Pacific Northwest National Laboratory (PNNL), 2024).

The DOE methodology for residential energy code cost-effectiveness calculates three different metrics: lifecycle cost (LCC), simple payback, and annual cashflow (Salcido, Xie, Tillou, & Mendon, 2024). The simple payback is only a function of the estimated incremental cost of all measures in the proposed code and annual energy cost savings, while the LCC and annual cashflow account for the impact to a home mortgage, taxes, measure replacements, inflation, and discount rates for the mortgage period. These metrics are estimated for a set of building prototypes representing homes and buildings with different foundation types and fuels in different climate zones. The results are weighted across the configurations to determine representative performance according to established metrics for the entire country.

The commercial DOE cost effectiveness methodology also includes LCC and simple payback but adds savings-to-investment ratio (SIR) and the ASHRAE 90.1 scalar ratio (Tyler, Tillou, & Rosenberg, 2024). The SIR is simply the ratio of the present value of benefits to the present value of costs but accounts for the same inputs as the LCC, and the scalar ratio is the sum of the incremental first costs and present value of the replacement costs divided by the energy cost savings minus the incremental maintenance costs.

In both methodologies, the energy savings are determined by modifying a set of DOE building prototypes based on the baseline (the previous code) and proposed energy codes and modeling with representative typical meteorological year (TMY3) weather files for the relevant climate zones. These files are selections of 12 "typical" months from recent history (in the case of TMY3, the range is 1991-2005). The cost effectiveness uses annual energy savings between the modeled baseline and proposed codes.

Notably, these methodologies do not include any evaluation or monetization of the myriad energy resilience benefits to building owners, occupants, or the grid. Metrics for building energy resilience and valuation methods are discussed later in this paper.

However, in the most recent editions of the methodologies, an appendix describes how to account for “advanced benefits” including GHG emissions reduction, job creation, health impacts, resilience impacts, grid impacts, and avoided future costs through readiness measures (Tyler, Tillou, & Rosenberg, 2024) (Tyler, Tillou, & Rosenberg, 2024). While the base methodologies also require using TMY3 weather files, the resilience impact section recommends also evaluating performance under extreme weather conditions, which are not represented in TMY3 files. New methods are making it possible to embed extreme weather events into TMY files, more accurately reflecting likely future scenarios than TMY alone (Tarkhan 2025).

Integrating Energy Resilience Benefit Valuation in Energy Code, Policy, and Program Cost-Effectiveness

Energy resilience benefit valuation seeks to identify benefits beyond energy savings attributable to energy measures, quantify them according to metrics, and assign them monetary value so they can be integrated into cost-effectiveness frameworks. This process enables a more complete evaluation of benefits of energy measures to aid decision-making around comparative outcomes. In a 2024 report, the DOE notes that while current energy code development does not pursue resilience criteria, the nature of many energy efficiency measures provide inherent energy resilience benefits (U.S. Department of Energy 2024). They further note the need to establish analytical methods, standards, metrics, and assumptions to further embed resilience within model and stretch energy codes (U.S. Department of Energy 2024). Primary categories of energy resilience benefits include but are not limited to building owner/operator benefits, occupant health and life-safety benefits, occupant productivity benefits, and energy grid benefits.

Grid Resilience Benefits of Energy Codes

Energy codes support grid resilience by reducing building energy use and flattening peak demand profiles. Beyond the benefits of energy efficiency to the grid, modern energy codes either require or allow compliance credit for grid-interactive technologies like load management and demand responsive controls and systems. The benefits of building-grid integration are discussed in ASHRAE’s 2023 guide on Grid Interactive Efficient Buildings and include reduced carbon emissions, cost savings, improved passive survivability and comfort, and utility rate increase mitigation (GEBs) (ASHRAE, 2023). Additionally, research has demonstrated how advanced energy codes support grid level resilience and building level occupant health and safety (Grant, et al., 2026).

Load management requirements are included in both ASHRAE 90.1 and the IECC, and many states and jurisdictions, including California and New York, have moved demand responsive controls into the mandatory requirements of the energy code. California’s Title 24 also has minimum energy storage system requirements for commercial buildings, reflecting the increasing need for building storage and load management as they lead the way in renewable generation penetration on the electric grid.

Occupant Health and Safety Benefits of Building Energy Resilience

There is a vast and ever-growing literature on the health risks posed by extreme heat. A detailed discussion is beyond the scope of this paper, but it is well established that heat exposure exacerbates the risks of premature deaths, hospital admissions, respiratory symptoms and emergency room visits; it is the major cause of weather-related deaths in the U.S. One U.S. study found all hospital related admissions for the elderly increased by 3% during extreme heat events and heat waves, and by 15% and 4% for renal and respiratory diseases respectively (Gonlund, Zanobetti, Schwartz, Wellenius, & O'Neill, 2014). The health effects of heat exposure on hospitalization can last a week or more after the heat exposure in older populations, especially in cooler climates and after hurricanes and major power outages (Gronlund, Zanobetti, Schwartz, Welleniu, & O'Neill, 2014) (Anderson, et al., 2013) (Skarha, Gordon, & Sakib, 2021). These cascading consequences underscore the importance of resilient buildings and energy systems in context of a warming world.

Passive cooling measures have been shown in various modeling studies of new and existing homes to reduce indoor overheating and its health impacts, especially during power outages (Sun, et al., 2021) (Mitchell, Stephens, & Heidarinejad, 2026). One study throughout U.S. climate zones indicated that passive cooling measures associated with modern energy codes and above-code energy measures could reduce overheating hours and excess mortality risk when compared to existing buildings (Franconi et al 2023). The benefit-cost ratios of beyond code design, based on energy savings, GHG reductions, and reduced heat mortality, ranged from 1 to 3 for new single families, from 0.39 to 3 for multifamily and less than one for existing multifamily. The extent to which building energy efficiency measures can address and mitigate these risks is becoming clearer as studies and real-world examples continue to strengthen the evidence base for resilience benefits.

Productivity and Financial Benefits of Building Energy Resilience

The benefits of resilience measures extend beyond health. These include office and worker productivity, benefits to attention and performance in academic environments, and the avoidance of building downtime (such as lost sales and backup fuel), relocation costs, damage to building equipment, and food spoilage in buildings. NREL/NLR has developed the Customer Damage Function Calculator, which assesses these and other factors pertaining to the operation of a building to analyze building costs associated with grid disruption events (National Laboratory of the Rockies (NRL), 2026). Literature reviews have presented the various impacts of indoor overheating on cognitive performance and productivity, demonstrating declines in cognitive performance as temperatures rise, and decreased performance in buildings that lack AC during heat waves (Hampo, Schinasi, & Hoque, 2024) (Federspiel, et al. 2004). All of the characteristics included in the novel definition of building energy resilience proposed in this paper can help prevent overheating and other damage functions.

Precedents for Expanding Energy Cost-Effectiveness Considerations

Several precedents exist for how the consideration of non-energy benefits or energy co-benefits may be included in energy code, policy, and program development. These include grid benefits, the social cost of carbon, and public health benefits associated with reduced criteria pollutants from fuel combustion in buildings or for electricity generation, The latter two are beyond the scope of this paper but still provide useful of examples of expanding cost-effectiveness considerations.

- **DOE / National Labs**: The methodologies for evaluating energy code updates for the 2024 energy code addressed how "advanced benefits" – such as emissions monetization, job creation, health impacts, resilience, grid reliability, and avoided future costs – could be included (Salcido, Xie, Tillou, & Mendon, 2024). The DOE Tri-lab s study further discusses how energy resilience can be integrated into energy code cost evaluations (Franconi, et al., 2023).
- **U.S. Environmental Protection Agency:** The EPA has incorporated a variety of benefit flows into their economic analyses per their Guidelines for Preparing Economic Analyses, which include economic, environmental, public health, and safety benefits (U.S. Environmental Protection Agency, 2024).
- **New York State** has allowed the consideration of and proposed methodologies for the inclusion of non-energy benefits or energy co-benefits in energy code, policy, and program cost effectiveness studies.
- **California Energy Commission (CEC)**: In February 2024, several organizations filed a petition to initiate formal rulemaking proceedings for including non-energy benefits in CEC planning and decision-making (California Energy Commission (CEC), 2024). Subsequently, the CEC granted the request to formally begin a process to determine methodologies for integrating these non-energy benefits into planning and decision-making processes.
- **The United Kingdom (UK):** Developed the Future Homes Standard, requiring new builds to be significantly more efficient, emit less carbon, and be more resilient than 2013 construction standards (Smith, 2026). The impact assessment for the regulations included consideration of transition costs, energy savings, value of carbon savings, and air quality savings (Ministry of Housing, Communities & Local Government, 2019).
- **ASHRAE**: In early 2026 the ASHRAE 90.1 standards committee voted on a cost effectiveness methodology that included fuel adders for the social cost of carbon to be used in development processes through the 2028 standard development cycle.

Methodologies for Energy Resilience Benefit Valuation Already Exist

Emerging research has identified methodologies for assessing the benefits of and assigning monetary value to energy resilience in buildings (Franconi 2023) (Leddy, et al. 2023). Among these, the 2023 tri-lab study completed in partnership by PNNL, NREL, LBNL, and the DOE explores the link between building energy efficiency and building energy resilience, proposing a framework for evaluating risk to occupants and property and the monetary value of damage to both (Franconi 2023). These methods analyze both building and energy and power system-level resilience to identify, establish, or assign metrics to evaluate relative performance. Metrics for evaluating energy resilience have been proposed in previous studies, and the authors recommend the use of metrics outlined in Table 2 for assessing building energy resilience (Franconi, et al., 2023) (Grant, et al., 2026) (Bianchi, et al., 2025). Performance according to these metrics can then be used to estimate avoided costs due to increased energy resilience. While building-level resilience valuation is perhaps more directly applicable to building energy codes, energy resilience measures at the building level can and do contribute to broader power sector-level resilience, and associated metrics and benefits should not be ignored or overlooked.

Table 2 Recommended metrics for evaluating building energy resilience

Summer passive survivability hours/days of safety	Number of hours/days that indoor conditions will remain within established safety targets during the summer evaluation period with no grid-delivered electricity (e.g., a heat wave event)
Winter passive survivability hours/days of safety	Number of hours/days that indoor conditions will remain within established safety targets during the winter evaluation period with no grid-delivered electricity (e.g., a winter storm event)
Hours/Days of safety	Drawing on to metrics in Tables 2 and 3, the number of hours/days, inclusive of active emergency power systems
% Safety Hours Bins	Hours that are in established safe, high-risk, and fatal hour bins (similar to metrics in Tables 2 and 3)
Peak to average ratio	Ratio of a buildings peak load to average load
4-hour Dispatchable Flexibility	% of a buildings load that can be automatically reduced through control signals for a minimum 4-hour duration

A 2023 NREL/NLR literature review presents methods of measuring and valuing resilience with a focus on the power sector, identifying methods for monetizing energy resilience like leveraging the value of lost load and customer damage functions in cost-benefit analyses, in addition to the use of social metrics like loss of life, hospitalizations, and economic stability impacts (Leddy, et al. 2023). This report offers a preliminary framework for how the grid benefits associated with building energy resilience measures may be identified, calculated, and assigned monetary value for the purpose of assessing full-scope energy resilience benefits. Ultimately these calculations can inform decision-making on energy code, policy, and program development, adoption, and implementation.

Some States Are Using their Own Cost Effectiveness Methodologies

New York State develops their own cost effectiveness studies for the state level energy code, using the DOE methodology as a basis (Davis, Heckman, Low, Naby, & LaRue, 2024). New York integrates environmental societal impacts into state energy planning and code analyses. The state's Energy Law Section 11-103 established a legal definition for a "cost-effective" code that includes the "secondary or societal effects, such as reductions in greenhouse gas emissions, as defined in regulations." (New York State, 2024). NYSERDA further detailed the methodology for assessing secondary or societal effects in Part 510 of Title 21 (NYSERDA, 2024). The methodology integrates the social cost of carbon to monetize the societal benefits associated with avoided greenhouse gas emissions associated with energy savings. NYSERDA's methodology does not currently account for impacts on health that fall outside of the scope of impact of greenhouse gas emissions – such as those from criteria pollutants (NOx, SO2, VOCs, and PM2.5); indoor air quality health benefits and associated avoided respiratory illness; productivity benefits; or energy resilience.

Publicly owned and leased facilities in Washington state are subject to a requirement that an Energy Life-Cycle Cost Analysis (ELCCA) be performed during their design phases. This practice has been in place since the Energy Conservation in Design of Public Facilities Law was passed in 1975. RCW 39.35C.020 requires the state to ensure that energy conservation practices, greenhouse gas reduction practices, and renewable energy systems are employed in the design of major public facilities. In 2022, the law was updated to require that ELCCAs analyze the use of an all-electric energy system and direct the analysis to include the social cost of carbon associated with emissions from energy consumption. The ELCCA compares different system options to help public agencies select the most cost-effective one for a project: the total cost under a ELCCA accounts for the initial cost of construction, the cost of owning and operating the facility over its life, and the social cost of carbon.

California has embedded broader energy use considerations, benefits, and costs into the time variable "Long-term System Cost" metric, which is now assessed against for energy code compliance and includes factors such as (1) the cost of emissions and (2) impact on transmission and distribution costs (California Energy Commission, 2024).

Recommendations for Valuing Resilience in Energy Codes, Policies, and Programs

If energy resilience is to be incorporated into energy code, policy, and programs—including state, local, and utility energy efficiency and incentive programs—cost effectiveness processes will require a standard methodology for valuation. A framework that can be applied with limited additional energy modeling and analysis, and that uses publicly available inputs (e.g., weather files, grid outage profiles) or inputs shared with the existing cost effectiveness methodology (e.g., energy costs, energy models) is most likely to succeed. Additionally, the boundaries of analysis and assumptions need to be standardized. These inputs and assumptions include the identification of hazards, scenarios to evaluate (extreme heat or typical operation), climate or weather files to use, scenario occurrence frequency, performance impacts, and the scope and nature of impacts.

If and where resilience to future climate conditions and hazards is to be incorporated into evaluations of energy code or energy program cost effectiveness, then selecting appropriate weather files will be essential. Multiple alternative weather files exist, including extreme meteorological year (XMY) and future typical meteorological year (FTMY) files. Not all these files are publicly available or available for all TMY3 weather stations at this time, but they could be incorporated into the workflow of analysis and valuation where available. Even where resilience is not incorporated as a separate additional cash flow for the cost effectiveness analysis, using FTMY files to better predict how buildings will perform under future conditions is a starting point for evaluating resilience and aiding energy resilience design decisions.

Benefit value streams accrue to multiple stakeholders, and some may be more or less appropriate to establish as "in-scope" for energy code, policy, and program cost effectiveness and program design. These stakeholders are noted in research by the DOE and National Laboratories and include equipment manufacturers, utility operators, municipal staff, local and state governments, designers and architects, financiers and insurers, facility managers, building owners, and building occupants (Specian, et al. 2020). Identifying the appropriate scope of benefit inclusion will be necessary for any policy framework and may be better standardized at the state level to guide agencies and regulators in their use of energy resilience benefit valuation.

Once a methodology for valuing resilience is standardized and codified, implementation into future energy code cycles could require code proposals to provide details on the impact to energy resilience in addition to first costs and energy savings, and the cost effectiveness evaluator should incorporate the resilience valuation into their workflow. Similar to how economic parameters are revisited and refined over subsequent code development cycles, the inputs for energy resilience analysis would need to be revised based on changes to extreme weather file development or changing climate and grid conditions, and regional or local priorities. Table 3 outlines considerations for establishing energy resilience benefit valuation in a code, policy, or program framework.

Table 3 Energy Resilience Benefit Valuation Considerations

Consideration	Recommendations
Climate and Weather Files	Establish weather files for use in analysis and indicate if future climate files will be used. Recent historical files may reflect future weather conditions more closely than longer term historic files. Recognize that extreme weather events are increasingly expected and TMY is likely insufficient.
Scenario Risk and Vulnerability Assessment	Establish one or more risk profiles to evaluate energy resilience benefits. Include low probability recent past or future weather events as a scenario risk and vulnerability profile.
Scope of Additional Benefits	Establish the scope of additional benefits to be considered. Begin with occupant life-safety, grid reliability, demand flexibility benefits, and reduced downtime.
Methodologies for Calculation	Establish clear and consistent analysis methodologies that reflect the scope of additional benefits to be considered. This may include simulation methodologies that allow for consistent and comparable analysis of building configurations and energy resilient measures
Policy and Program Metrics	Identify and report on metrics that reflect benefits to multiple stakeholders and align the use of these across energy policies and programs. See table 3 below.
Balance Competing Priorities	Given the multi-stakeholder nature of energy resilience benefits, it is essential to identify potential conflicts in pursuing energy resilience through policies and programs (such as how building level system operation make benefit the grid at the expense of building resilience, or vice-versa).

Conclusions and Next Steps

Energy resilience has significant benefits to multiple stakeholders, not least of which are vulnerable and sensitive building occupant populations. Large parts of the U.S. population are vulnerable to the adverse health effects of heat due to chronic health conditions such as heart disease, respiratory disease, kidney disease, hypertension, diabetes, obesity, neurological disease, and/or use of medications that affect sweating or hydration. Infants, young children, pregnant women, and older adults are especially sensitive to heat exposure.

Energy resilience has the potential to address challenges related to electric demand and load growth, climate change, energy affordability, occupant life-safety, and grid-modernization. Energy codes, policies, and programs already provide energy resilience benefits to multiple stakeholders. These benefits are often not reflected at all, or are undercounted, in policy and program cost effectiveness evaluations and reporting. Given the historical purpose of building codes to protect safety, health, and quality of life, energy resilience is arguably a basic occupant life-safety. The authors contend that building energy resilience is in-scope for the IRC and IBC and that minimum performance thresholds (such as 24-hour summer and winter safety, 0% fatal hour, and 20% 4-hour dispatchable flexibility) should be established and included in building codes without being tested for cost-effectiveness.

Beyond these minimum energy resilient performance requirements, energy code cost effectiveness evaluations should adopt standardized methodologies to evaluate energy resilience measures according to their monetized benefits. Such valuation would enable more informed decision-making for code development through the cost-effectiveness tests.

Methodologies already exist. The DOE and PNNL have been instrumental in establishing and distributing methodologies for energy code cost-effectiveness evaluation. Given the relatively early stage of energy resilience benefit valuation, federal leadership and direction would help to standardize approaches for use in energy code cost-effectiveness and could support integration into national model code frameworks and broader adoption across other energy policies and programs. Absent federal direction, some states leading in energy and climate policy development, including California and New York, are already positioned to support the establishment of standardized approaches to energy resilience benefit valuation. These early mover states can pilot and test energy resilience valuation in different energy policy and program structures such as energy codes and state or utility incentive programs.

It is important to note that, sometimes, actions to increase resilience to known or anticipated events can negatively impact others, such as a utility shedding load to maintain overall grid stability at the expense of individual building electric energy storage capacity, or a building operator draining pipes in anticipation of a loss of power and heat during a winter storm to prevent flooding and equipment damage, limiting certain functions or services provided to occupants of the building. Requirements around operational capability and configuration for building energy resilience should be aware of and mindful not to create or exacerbate existing inequities in building design, construction, and operation. How to address and resolve these competing priorities and potential conflicts should be further explored in future studies.

There is clear potential to align stakeholder priorities and to leverage disparate funding streams and market mechanisms towards deeper energy resilience through building energy code, policy, and program design, adoption, and implementation. Given this multi-stakeholder nature of energy resilience benefits, it may be appropriate to look at holistic implementation models that leverage multiple policy and program levers to distribute and cover incremental first costs. State level incentives, utility incentives, code and policy mandates, green bank and revolving loan funds, and private investment all offer pathways for scaling market adoption of building energy resilience. Aligning incentives, regulatory frameworks, and market conditions towards greater building and grid level energy resilience will support the most beneficial outcomes.

In the early stages of adopting and integrating energy resilience benefit valuation it will be essential to establish clear boundaries for scope of inclusion and consideration. Attention should be paid to how and to whom financial benefits accrue and to align financial obligations accordingly (e.g., utilities can provide additional financial support for building energy resilience measures that provide utility grid benefits).

This paper proposed an expanded definition of “building energy resilience” that includes passive survivability, grid interactivity, and active emergency power measures at the building level. Further integrating this definition of building energy resilience into energy codes, policies, and programs can support alignment of regulatory and program structures.

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